International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 5 Issue 4, May-June 2021 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Experimental Investigation on Plastic Sand Aggregate as a Partial Replacement for Coarse Aggregate in Concrete

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ABSTRACT

The attempt is made on using plastic-sand aggregate as a partial replacement for coarse aggregate in concrete. In this project work, conventional aggregate is replaced by 5, 10 & 15percentage of plastic-sand aggregate in M20 grade of concrete. The compressive strength and split tensile strength of concrete mix at 7th, 14th and 28th day of curing period is determined along with the workability property of fresh concrete and results are analyzed and compared with the conventional mix.

KEYWORDS: *plastic-sand, partial replacement, compressive strength, split tensile strength*

How to cite this paper: M. Saravanan | V. Revathi "Experimental Investigation on Plastic Sand Aggregate as a Partial Replacement for Coarse Aggregate in Concrete" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-5 | Issue-4, June 2021, pp.88-90, URL: www.ijtsrd.com/papers/ijtsrd41170.pdf

IJTSRD41170

1. INTRODUCTION

Concrete is a composite material composed of coarse and fine aggregate bound together with fluid cement and harden over time. Most concrete used are Portland cement based concrete made with other hydraulic cements.

Besides, abundant raw materials are exhaustively utilised in cement production and their availability becomes challenging in near future. The river sand used as fine aggregate is being met huge demand in construction industry. Good quality coarse aggregate is also not available everywhere. Further, enormous quantities of solid wastes are generated in the world. According to the "Swachhata Sandesh Newsletter" by the MoHUA, as of January 2020, 147,613 metric tonnes (MT) of solid waste is generated per day. Among various solid wastes, it is noticed that plastics wastes are about 8% by weight of the total solid wastes. Being a non-biodegradable, the disposal of plastic wastes is a big concern in the world. Reuse of plastic could be a solution in effective way instead of land filling[1].One of the ways is to use it as coarse aggregate in concrete. Several works were attempted to use plastics as aggregates in concrete[2-8].

In this work, the waste plastic bags are taken as partial replacing material for coarse aggregate for construction practices. The waste plastic product is named as PLASTIC SAND AGGREGATE (PSA) which is having similar characteristic like coarse aggregate. The study leads about strength and behaviour of partially replaced plastic sand aggregate in concrete.

Plastic Sand Aggregates

Plastic-sand aggregates (PSA) are obtained by mixing the fine aggregate (sand) with the molten waste plastic bags to get a hard aggregate like substance. The plastic bags are heated at the range of 90ºC-110ºC to get a molten gel like substance.

Preparation of Plastic Sand Aggregate

Fig1.1PlasticSand aggregate

Waste plastic bags are collected and unwanted waste is removed from it. River sand used for the construction is used in the manufacturing of the aggregate. River sand should be free from impurities and any organic matters. A steel pan is used for melting the plastic bags. Plastic bags are placed at the heated pan after few minutes the plastic bags will starts to melt down Plastic bags are heated thoroughly until it comes to a gel like substance Once the plastic bags are completely melted, river sand is added to that molten plastic

gel and mixed thoroughly to get a paste like substance Once the paste like substance is achieved it is taken out carefully and placed in a 2 mould as per the requirement. The time between taking the paste from the heater and placing should not exceed 2 minute The setting time of plastic and aggregate is less than 2 minutes so it should be demoulded from the mould within a minute. The preparation process of plastic-sand aggregates is shown in Fig 1.1.

2. EXPERIMENTAL WORK

Materials

Cement: Confirming to IS 12269:1987 Specification for 53 grade ordinary Portland was used

Aggregates: Confirming to IS 383:1970 – Specification for coarse and fine aggregates from natural sources for concrete and plastic sand aggregates

Water: Potable water

Mix Design of M_{20} Grade Concrete

The detailed description about the M_{20} grade of concrete is derived as follows. The mix ratio of the M_{20} grade of concrete is 1:1.5:3, which implies that one part of cement, one and half part of fine aggregate and three parts of coarse aggregates. The water cement ratio is taken as 0.52 for the preparation of cubes and cylinders. Totally 12 cubes and 12 cylinders were prepared for the7th, 14th & 28th day testing with coarse aggregate replaced at the increasing range of 0%, 5%, 10% and 15% by plastic-sand aggregate, 3 cubes and 3cylinders were prepared as an ordinary concrete without any replacement. 3cubes and 3 cylinders were prepared with 5% replacement of coarse aggregate by plastic-sand aggregate. 3 cubes and 3 cylinders were prepared with 10%replacement of coarse aggregate by plastic-sand aggregates. 3 cubes and 3cylinders were prepared with 15% replacement of coarse aggregate by plastic sand aggregate.

Mixing and Casting

After the required amount of materials is obtained for every various proportions, mixing is started. First the Ordinary Portland cement and the fine aggregate is taken in mixing pan and it is mixed thoroughly using the trowel. After cement and fine aggregate is mixed thoroughly coarse aggregate is added with their respective replacement proportions of 5%, 10% and 15% by plastic sand aggregate (PSA) and mixed using a trowel.

Once the dry mixing is finished water is added to the mix uniformly and at the same time it is mixed thoroughly by means of trowel. Then the concrete obtained is placed in cubical specimen of 150x150x150 mm in size and in the cylindrical specimen of 300mm height in and 150mm in diameter. The concrete preparation and filling in the mould is presented in Figure 2.1.

Fig 2.1Mixing and concrete filling in the mould

Curing

Curing is the process of controlling the rate and extent of moisture loss concrete during cement hydration. It may be either or after it has been and in position, thereby providing time for the hydration of the cement. Curing must be undertaken for a reasonable period of time (28 days as Indian standard) if the concrete is to achieve its potential strength and durability. Curing was done till the day before the testing of specimens. The curing of concrete specimens are shown in Figure 2.2.

Fig 2.2 Normal water curing of concrete

3. RESULTS AND DISCUSSIONS

Compressive Strength of Concrete

Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete works. The compressive strength of concrete is one of the most important and useful properties of concrete. In most structural applications concrete is employed primarily to resist compressive stresses. In those cases where strength in tension or in shear is of primary importance, the compressive strength is frequently used as a measure of these properties.

The test is done as per IS: 516-1959. Tests should be done at recognized ages of the test specimens, usually being 7th and 28th days. The ages should be calculated from the time of the addition of water to the drying of ingredients. Compression test is the most common test conducted on hardened concrete, partly because an easy test to perform, and partly becomes most of the desirable characteristic properties of concrete are qualitatively related to is compressive strength. The compression test is carried out on specimens cubical or cylindrical in shape. The cube specimen should be in the size 150x150x150mm.

Compressive strength = P/A

Where,
P-Maximum load on specimen,
A-area of the cubical specimen
The testing of cube specimens is displayed in Figure 3.1

Fig 3.1 Compressive strength testing of concrete cube

Table 3.1 Compressive Strength of PCA Concrete

% of Replacement	Compressive strength(N/mm²)		
	7 days	14 days	28 days
0%	11.46	17.11	23.78
5%	12.53	18.49	24.93
10%	13.55	19.51	26.09
15%	11.15	16.71	23.51

The compressive strength results of PCA concrete is portrayed in Table 3.1. The PCA replacements were made from 0% to 15% for coarse aggregate. The test results reveal that 10% PCA replacement produced maximum compressive strength compared to conventional concrete made without PCA.

Split Tensile Strength of Concrete

The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compressive testing machine and the load is applied until failure of the cylinder, along the vertical diameter. When the load is applied along the generatrix, an element on the vertical diameter of the cylinder is subjected to a horizontal stress. The testing of cylindrical specimen is shown in Figure 3.2.

Fig3.2 Split tensile strength testing of concrete cylinder

Table Split tensile strength of cylinder

% of Replacement	Compressive strength(N/mm²)		
	7 days	14 days	28 days
0%	2.15	2.66	3.04
5%	2.46	2.77	3.26
10%	2.70	2.98	3.53
15%	2.02	2.40	2.77

The split tensile strength results of PCA concrete is represented in Table 3.2. The PCA replacements were made from 0% to 15% for coarse aggregate. Similar to compressive strength, the test results reveal that 10% PCA replacement produced maximum split tensile strength compared to conventional concrete made without PCA.

4. CONCLUSIONS

From the results obtained from the above chapters, the following conclusion were made,

The compressive and split tensile strength of concrete is increased when 10% of coarse aggregate is replaced with the plastic-sand aggregate. Beyond 10% PCA replacement, slight reduction in the compressive strength and split tensile strength is observed.

8% increment in the compressive strength is found at 10% replacement of natural aggregate by plastic-sand aggregate at 28 days when compared to conventional concrete. And the strength decreases by 3.5% when the natural aggregate is replaced by plastic-sand aggregate.

16% increment in the split tensile strength is found at 10% replacement of natural aggregate by plastic-sand aggregate at 28 days when compared to conventional concrete. And the strength decreases by 8% when the natural aggregate is replaced by plastic-sand aggregate.

The 10% of plastic-sand aggregate is found to be the optimum percentage at which the coarse aggregate can be replaced.

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